ADOT ECS File: JPA 98-27
Project No. SPR-467
TRACS No.: R0467 10P
Research: Effective Countermeasures
to Reduce Accidents in Work Zones

INTERAGENCY AGREEMENT
BETWEEN
THE DEPARTMENT OF TRANSPORTATION
AND
THE ARIZONA STATE UNIVERSITY

THIS AGREEMENT is entered into 17 April, 1998, between agencies of the State of Arizona, to wit; the DEPARTMENT OF TRANSPORTATION (the "DOT") and the ARIZONA BOARD OF REGENTS, acting for and on behalf of ARIZONA STATE UNIVERSITY, (the "University").

I. RECITALS

1. The DOT is empowered by Arizona Revised Statutes Section 28-401 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the DOT.

2. The University is empowered by Arizona Revised Statutes Section 15-1626 to enter into this agreement and has delegated to the undersigned authority to execute this agreement on behalf of the University.

3. The DOT and the University desire to conduct research and achieve the development and implementation of effective countermeasures to reduce accidents in work zones, at an estimated cost of $30,000.00, all at DOT expense, hereinafter referred to as the Project.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

II. SCOPE OF WORK

1. The DOT will:

a. Appoint a Project coordinator within the DOT's Transportation Technology Group to interface with the University relating to the research and development.

b. Provide the University with information and data as may be reasonably available to assist in the Project research and development.

c. Reimburse the University within forty-five (45) days after receipt and approval of monthly invoices, in a total amount not to exceed $30,000.00.

2. The University will:

a. Appoint a Project coordinator at the University (ASU) to interface with the DOT relating to the research and development.

b. Accomplish the research and development generally in accordance with Exhibit A, which is attached hereto and made a part hereof, including effective countermeasures to reduce accidents in work zones, and a final report documenting the program, data derived, and the final results. Such reports will be in a format compliant with the DOTs "Guidelines for Preparing Research Reports."

c. No more often than monthly, invoice the DOT in the form of Exhibit B attached hereto, supported by narrative reports and an accounting of monthly costs and expenditures on the Project. Upon completion of the Project, provide the DOT with a detailed final report.

III. MISCELLANEOUS PROVISIONS

1. Title to all documents, reports and other deliverables prepared by the University in performance of this agreement shall rest jointly with the DOT and the University.

2. This agreement shall become effective upon signature by the parties hereto, and shall remain in force and effect until completion of said Project and reimbursements; provided, however, that this agreement, may be cancelled at any time prior to the commencement of performance under this agreement, upon thirty (30) days written notice to the other party.

3. The parties agree to comply with all applicable state and federal laws, rules, regulations and executive orders governing equal employment opportunity, immigration, nondiscrimination and affirmative action.

4. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.

5. The provisions of Arizona Revised Statutes Section 35-214 are applicable to this contract.

6. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

7. All notices or demands upon any party to this agreement relating to the agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Department of Transportation Joint Project Administration 205 S. 17th Avenue - 616E Phoenix, AZ 85007	Arizona State University Research & Creative Act. PO Box 871603 Tempe, AZ 85287-1603

8. The parties recognize that performance by ASU under this Agreement may be dependent upon the appropriation of funds by the State Legislature of Arizona. Should the Legislature at any time fail to appropriate the necessary funds for such performance, the, by written notice to the DOT, ASU may cancel this Agreement.

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

STATE OF ARIZONA

THE ARIZONA BOARD OF REGENTS acting for and on behalf of ARIZONA STATE UNIVERSITY

4-6-98

By _____
JANICE D. BENNETT, Director
Office of Research and
Creative Activities

DEPARTMENT OF TRANSPORTATION

By _____
TIM WOLFE
Ass't State Engineer

98-27
17mar

JPA 98-27

RESOLUTION

BE IT RESOLVED on this 17th day of March 1998, that I, the undersigned MARY E. PETERS, as Director of the Arizona Department of Transportation, have determined that it is in the best interests of the State of Arizona that the Department of Transportation, acting by and through the Intermodal Transportation Division, to enter into an agreement with ASU for the purpose of defining responsibilities for developing effective countermeasures to reduce accidents in work zones.

Therefore, authorization is hereby granted to draft said agreement which, upon completion, shall be submitted to the Assistant State Engineer for approval and execution.

DAVID ALLOCCO, Manager
Engineering Technical Group
for Mary E. Peters, Director

EFFECTIVE COUNTERMEASURES

TO REDUCE ACCIDENTS IN WORK ZONES

Proposed to Arizona Department of Transportation

Submitted February, 1998

by Jonathan Upchurch, P.E.

Department of Civil and Environmental Engineering
College of Engineering and Applied Sciences
Arizona State University
Tempe, Arizona 85287-5306

Janice D. Bennett, Director
Office of Research and Creative Activities
(602) 727-6527 (Lori Gabriel)

TABLE OF CONTENTS

IDENTIFICATION

This project, entitled **"Effective Countermeasures to Reduce Accidents in Work Zones,"** will be conducted by:

Department of Civil and Environmental Engineering
College of Engineering and Applied Sciences
Arizona State University
Tempe, AZ 85287-5306.

Dr. Jonathan Upchurch, Professor, Department of Civil and Environmental Engineering, will serve as Principal Investigator and Project Director.

Address:
Dr. Jonathan Upchurch, P.E.
Professor
Department of Civil and Environmental Engineering
Arizona State University
Tempe, AZ 85287-5306

Telephone:
602/965-1713
FAX:
602/965-2728
E-Mail:
jon.upchurch@asu.edu

All correspondence regarding technical aspects of the study should be delivered to Dr. Upchurch.

All other correspondence, including contractual matters, should be delivered to:

Lori Gabriel
Office of Research and Creative Activities
Arizona State University
P. O. Box 871603
Tempe, AZ 85287-1603

Telephone:
602/727-6527
FAX:
602/965-0649
E-Mail:
lori.gabriel@asu.edu

with a copy delivered to Dr. Upchurch.

Frank McCullagh will serve as project monitor on behalf of the Arizona Department of Transportation.

Address:
Mr. Frank McCullagh
Arizona Department of Transportation
Arizona Transportation Research Center
1130 North 22nd Avenue
Phoenix, AZ 85009

Telephone:
602/407-3132
FAX:
602/256-6367
E-Mail: A2279@atrc.dot.state.az.us

This proposal was prepared by Dr. Jonathan Upchurch, P.E.

PROBLEM STATEMENT

Work zone fatalities reached an all time high in 1994 nationwide when 833 people were killed in work zone related accidents. This represented a 29 percent increase over the 1992 level, which was the lowest recorded number of fatalities in ten years.

It has been clearly demonstrated that work zones are more hazardous than the typical roadway environment. Considering exposure (such as vehicle-miles traveled), accidents are higher in work zones than on roadways in general. For that reason, work zone safety continues to be a high priority for traffic engineering professionals and highway agencies.

Work zone fatalities and injuries include not only the occupants of vehicles but also pedestrians. In many instances these ``pedestrians'' are workers in the work zone, either construction workers or public agency employees who are maintaining the roadway.

The following statistics summarize the extent of the problem in Arizona. This summary is for reported accidents in the 1995 calendar year.

Type of Unusual Road Condition	Number of Crashes				No. of Victims	
	Total	Fatal	Injury	PDO	Killed	Injured
Under Construction Thru Traffic Allowed	3,049	19	940	2,090	19	1,483
Under Construction Traffic Detoured	62	0	20	42	0	32
Under Repairs	129	0	51	78	0	66
Temporary Lane Closure	385	1	124	260	2	219

It is estimated that the statewide economic loss due to the above accidents is $70 million.

Improving work zone problems and work zone safety has even been the focus of recent legislation. The Intermodal Surface Transportation Efficiency Act (ISTEA) specifically required the Secretary of Transportation to develop and implement a work zone safety program to improve safety at construction zones and to develop a uniform accident reporting system.

Currently there is significant on-going research that is studying procedures for determining work zone speed limits, establishing their effectiveness and implementability and improving traffic

control device design and placement. These studies will provide additional needed knowledge to procedures for ensuring safer and more convenient work zone experiences.

Due to its importance and the amount of previous and on-going research efforts, there is a need to prepare a state-of-the-practice report to synthesize current knowledge and to formulate recommendations for reducing accidents in work zones.

OBJECTIVES OF THE PROJECT

The objectives of this project are:

Characterize the nature of work zone accidents in Arizona.

Prepare a state-of-the-practice report on effective countermeasures to reduce accidents in work zones.

Recommend countermeasures which should be implemented in Arizona to improve work zone safety and to reduce accidents.

Prepare procedures and guidelines for implementing these countermeasures.

WORK PLAN

Introduction

A major problem of work zone accidents has been identified at both the national and Arizona levels. Arizona's overall goal is to reduce the number of work zone accidents, fatalities and injuries. Successful attainment of the above project objectives will help Arizona to meet that goal.

Approach

The work plan is structured to achieve the objectives described above through a logical progression of activities as described in the following tasks.

TASK 1 ANALYZE WORK ZONE ACCIDENTS

Arizona work zone accidents for calendar years 1992 through 1996 will be reviewed and analyzed. The ALISS accident records system will serve as the source of information for this study. Through ALISS, information on accidents occuring in all jurisdictions and on all roadway networks (state, county, city) will be obtained and evaluated.

Accidents occuring in work zones will be identified by the ``unusual condition'' category in the accident records database. Accident records with the following coding will comprise the set of accidents to be evaluated in the study.

02 - Under construction - through traffic allowed
03 - Under construction - traffic detoured
04 - Under repairs
12 - Temporary lane closure

This set of accidents will be sorted and summarized in a variety of ways to identify trends, patterns, circumstances and other ways of characterizing the work zone accident problem. Sorts and summaries will include (but not be limited to) the following.

By year
By severity
Number of accidents
Number of fatal accidents
Number of injury accidents
Number of Property damage only accidents
Number of fatalities
Number of injuries
Light condition
Weather condition
The type of unusual condition (02, 03, 04, 12, above)
Whether injured and fatal individuals were vehicle occupants or pedestrians (possibly work zone workers)

In addition, the hardcopy accident report forms for all fatal accidents occurring in work zones from 1992 through 1996 will be reviewed. It is estimated that there will be about 100 fatal accidents for the five year period. This review will seek to identify any qualitative factors which are common to fatal work zone accidents.

The products of Task 1 will be tabulations of data and analysis of those tabulations. Also included will be the qualitative analysis of fatal accidents. All of these products will be incorporated into the final report (Task 5). A presentation of accident findings will be made to the technical advisory committee at the conclusion of Task 1.

TASK 2 LITERATURE SEARCH

A review of the literature will be conducted to identify the range of countermeasures which have been used by other states, agencies, and countries to attempt to reduce work zone accidents. A preliminary literature search conducted for preparation of this proposal has identified a variety of countermeasures which have been used, such as the following.

Various strategies for establishing work zone speed limits
Regulatory signing (as opposed to advisory speed signing)
Presence of unoccupied police car

Police enforcement of work zone speed limits
``Double Fines in Work Zones'' signing and associated enforcement
Drone radar
Flagging
Changeable message signs
``Give 'Em a Brake'' signing
Rumble strips

A special effort will be made to locate documentation of the effectiveness of various countermeasures in reducing work zone accidents.

A list of references identified through a preliminary literature search is included in the appendix.

The findings of the literature search will be incorporated into the state-of-the-practice report (Task 3).

TASK 3 PREPARE STATE-OF-THE-PRACTICE REPORT

A state-of-the-practice report will be prepared which will summarize the findings of Task 2. It will describe the various countermeasures that have been used and, when available, document their effectiveness.

The report will be submitted to the technical advisory committee. It is also proposed that a presentation will be made to the technical advisory committee.

Before proceeding with Task 4, it is suggested that the research team meet with the technical advisory committee to discuss the countermeasures that might be adopted in Arizona. This discussion should consider various countermeasures in view of practicality of implementation, consistency with agency policies, any need to change state law, and other factors. It may be worthwhile to include participation from the Department of Public Safety in this discussion.

TASK 4 PREPARE PROCEDURES / GUIDELINES

Task 4 will recommend countermeasures which should be implemented in Arizona to improve work zone safety and to reduce accidents. Procedures and guidelines for implementing these countermeasures will be prepared.

These procedures and guidelines may include standard provisions to be incorporated in traffic control plans, changes in agency policy, recommended changes to state law, or proposed changes to Part VI of the Manual on Uniform Traffic Control Devices.

The recommended countermeasures, the procedures and guidelines will be documented in the final report (Task 5).

TASK 5 PREPARE FINAL REPORT

A final report will be prepared documenting the research effort and discussing the conclusions and recommendations.

Benefits

It is expected that the recommended countermeasures, the procedures and the guidelines will help Arizona to reduce the toll of accidents in work zones. In 1995 this toll included 21 fatalities, 1800 injuries, and 2,470 property damage only accidents with an associated economic loss of $70 million.

Work Time Schedule

The proposed project duration is seven months. The work time schedule, showing the major tasks and milestones is presented on the following page.

Implementation

It is anticipated that the procedures and guidelines developed in this study may include standard provisions to be incorporated in traffic control plans, changes in agency policy, recommended changes to state law, or proposed changes to Part VI of the Manual on Uniform Traffic Control Devices.

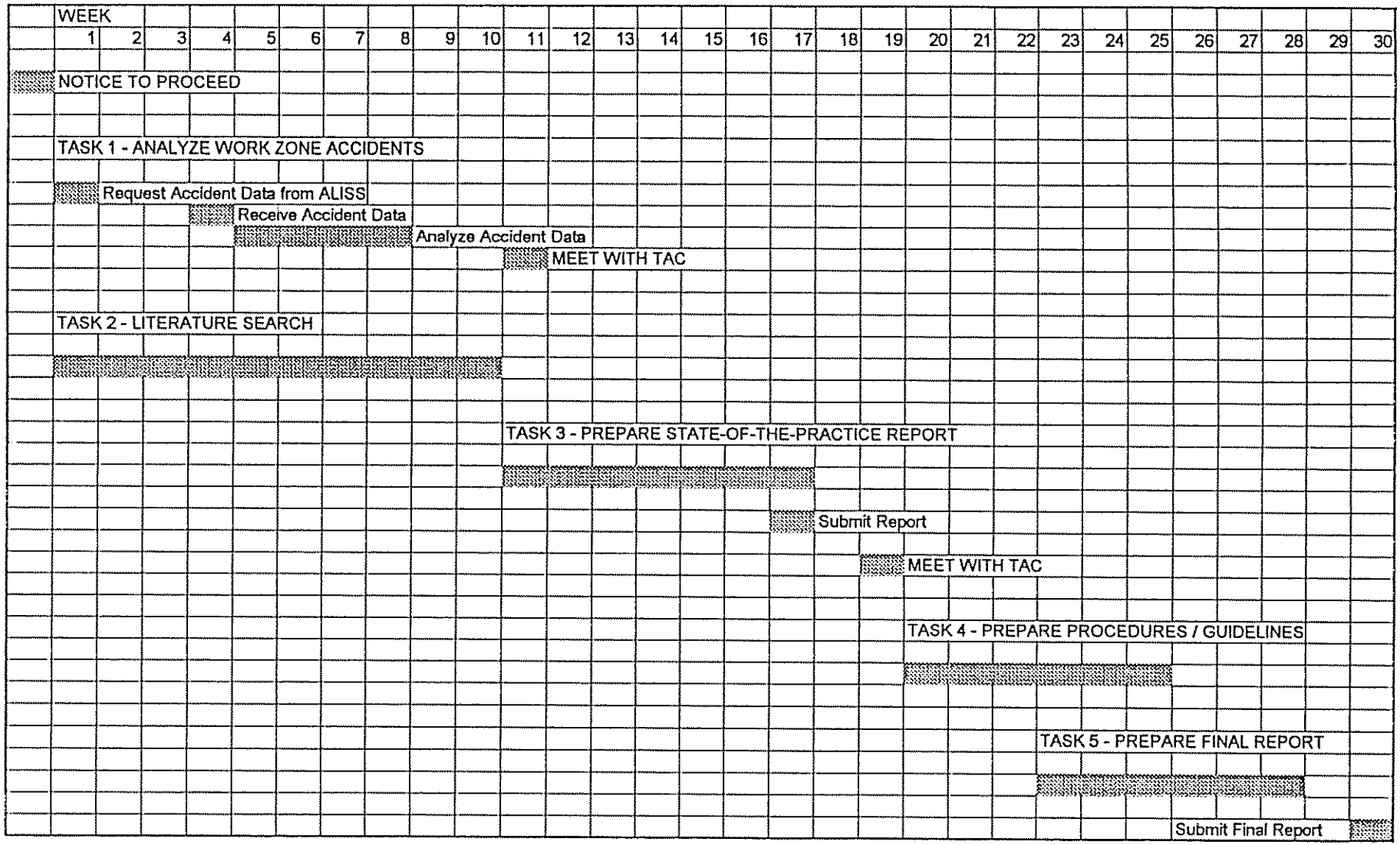
The necessary steps required for implementation will depend upon which of the above kinds of items are recommended. We will suggests steps and strategies for implementation in the final report.

Facilities Available

This project does not require specialized facilities. Arizona State University has state-of-the-art computer and communications capabilities for data analysis, report preparation, and communication with the project sponsor. These capabilities include telephone, conference calling capability, fax, overnight delivery, and electronic mail.
ASU has the facilities needed to carry out this project.

STAFFING PLAN

Dr. Jonathan Upchurch will serve as Principal Investigator for this project. He will be assisted by one or two graduate students in transportation engineering.


WEEK
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
NOTICE TO PROCEED
TASK 1 - ANALYZE WORK ZONE ACCIDENTS
Request Accident Data from ALISS
Receive Accident Data
Analyze Accident Data
MEET WITH TAC
TASK 2 - LITERATURE SEARCH
TASK 3 - PREPARE STATE-OF-THE-PRACTICE REPORT
Submit Report
MEET WITH TAC
TASK 4 - PREPARE PROCEDURES / GUIDELINES
TASK 5 - PREPARE FINAL REPORT
Submit Final Report

Qualifications

Dr. Upchurch's 26 year career includes extensive experience in traffic engineering and with traffic control devices in particular.

For the past 16 years he has engaged in transportation engineering teaching and research at Arizona State University. His research results have focused of practical applications with value to agencies such as ADOT.

Dr. Upchurch has held numerous leadership positions in the transportation community, both within Arizona and nationally. He has served as the Founding President of the Intelligent Transportation Society of Arizona and as International President of the Institute of Transportation Engineers.

Since 1979 Dr. Upchurch has been an active participant in the National Committee on Uniform Traffic Control Devices. The National Committee makes recommendations to the Federal Highway Administration on changes / improvements to the Manual on Uniform Traffic Control Devices. His experience with the National Committee includes the following.

Member, Research Committee	1983 - present
Member, Construction and Maintenance Technical Committee	1989 - present
Associate Member representing National Safety Council	1989 - 1990
Associate Member representing Institute of Transportation Engineers	1991 - 1997
Member representing Institute of Transportation Engineers	1997 - present
Executive Secretary of the Committee	1979 - 1988

His other relevant experience in field of Traffic Control Devices includes:

Served for six years as Chair of the Transportation Research Board's Traffic Control Devices Committee.

Authored 45 papers and made over 55 technical presentations dealing with traffic control devices.

Hired by FHWA in 1995 as a technical editor to review the proposed text of the next edition of the MUTCD.

Served on four NCHRP panels on traffic control device topics.

For this project, Dr. Upchurch's experience on the Construction and Maintenance Technical Committee of the National Committee is of particular importance, as is his participation in one of the

above NCHRP panels -- ``Procedures for Establishing Work Zone Speed Limits''.

Additional information on Dr. Upchurch's background and experience may be found in his vita (see Appendix).

Level of Effort by Tasks

The estimated contribution of each team member, in person-hours, to each task is presented below

	Dr. Upchurch	Student
Task 1 - Analyze Work Zone Accidents	35	140
Task 2 - Literature Search	25	140
Task 3 - Prepare State-of-Practice Report	40	85
Task 4 - Prepare Procedures/Guidelines	45	70
Task 5 - Prepare Final Report	42	85
Total	187	520

Cooperative Features

The research team will rely upon ADOT's Traffic Records Section for cooperation and access to the ALISS accident records database. Jim Williams' office has shown excellent cooperation with ASU on two recent accident studies; we expect we will maintain that same working relationship in carrying out this project.

BUDGET

Arizona State University estimates a total of 707 person-hours of time will be required to carry out this project.

As Principal Investigator, Dr. Upchurch is budgeted to devote 187 hours to this project

The student level of effort is estimated to be 520 hours.

The attached budget tabulation presents a total estimated cost of $30,000 and presents a breakdown by cost category. The budget is based upon the scope of work presented in this proposal.

BUDGET

DIRECT COSTS	
A. Salaries and Wages	
1. Principal Investigator - Dr. Upchurch 18 % time for 6 months = 187 hours	$10,275
2. Graduate Research Assistant (Master's level) 50 % time for 6 months = 520 hours at $12.18 per hour	$ 6,334
B. Fringe Benefits	
1. Faculty (25% of salaries)	$ 2,569
2. Students (4% of wages)	$ 253
C. Travel Expenses	
Local travel (auto mileage) 400 miles at $0.30 per mile	$ 120
D. Other Direct Costs	
Photocopy charges	$ 81
Long Distance Telephone	$ 40
TOTAL DIRECT COSTS	$19,672
FACILITY AND ADMINISTRATIVE COSTS (52.5 % OF TOTAL DIRECT COSTS)	$10,328
Fee / Profit	$ 0
TOTAL	**$30,000**

APPENDICES

Literature Review

This list of references was identified through a preliminary literature search.

Benekohol, Rahim F., Resende, Paulo T. V. and Wixiog Zhao, (1992, January), ``Speed Reduction Effects of Drone Radar in Rural Interstate Work Zones,'' Illinois Department of Transportation.

Freedman, M., N. Teed, and J. Migletz, (1994, January), `` The Effect of Radar Drone Operation on Speeds at High Crash Risk Locations,'' Insurance Institute for Highway Safety, Washington, DC.

Ullman, Gerald L., (1991, January), ``The Effect of Radar Transmissions upon Traffic Operations at Highway Work Zones,'' Preprint No. 910279, Transportation Research Board, 70th Annual Meeting, Washington, DC

McCoy, P.T., Bonneson, J.A., and Kollbaum, J.A., (1995, January), ``Speed Reduction Effects of Speed Monitoring Displays with Radar in Work Zones on Interstate Highways,'' Preprint No. 950322, Transportation Research Board, 74th Annual Meeting, Washington, DC.

Garber, Nicholas J. and Patel, Surbhi T., (1995, January), ``Control of Vehicle Speeds in Temporary Traffic Control Work Zones Using Changeable Message Signs with Radar,'' Preprint No. 950622, Transportation Research Board, 74th Annual Meeting, Washington, DC.

Choueiri, Elias M., Valenti, Robert A. and Sandhu, Deniz, (1995, January), ``Effectiveness of an Experimental Stop / Slow Signal Flag in Work Zones,'' Preprint No. 950438, Transportation Research Board, 74th Annual Meeting, Washington, DC.

Benekohol, Rahim F. and Lynn M Kastel, (1991), ``Evaluation of Flagger Training Session on Speed Control in Rural Interstate Construction Zones,'' Transportation Research Record No. 1304, Washington, DC.

Benekohol, Rahim F. and Jie Shu, (1992, April), ``Speed Reduction Effects of Changeable Message Signs in a Construction Zone,'' Illinois Department of Transportation.

Janssen, W. and Van der Horst, R., (1993, January), ``Presenting Descriptive Information in Variable Message Signing, `` Preprint No. 931074, Transportation Research Board, 72nd Annual Meeting, Washington, DC.

Benekohol, Rahim R. and Jie Shu, (1992, June), ``Evaluation of Work Zone Speed Limit Signs with Strobe Lights,'' Illinois Department of Transportation.

Van Der Horst, Richard and Wytze Hoekstra, (1994, January), ``Testing Speed Reduction Designs for 80 Km/H Roads with a Simulator,'' Transportation Research Board, 73rd Annual Meeting, Washington, DC.

Benekohol, Rahim F., Resende, Paulo T. V. and Robin L. Orloski, (1992, May), ``Effects of Police Presence on Speed in a Highway Work Zone: Circulating Marked Police Car Experiment,'' Illinois Department of Transportation.

Nelson, K., ``MHTD Pickup Look-Alike Helps Catch Speeders in St. Louis Work Zones,'' (1993, April), MHTD News.

``Radar Protects Road Workers,'' (1991, July), Roads and Bridges.

Culp, J.D., (1990, October 26), ``Field Testing of Radar Controlled Speed Sign for Construction Zones,'' Research Project 90 TI-1479, Office Memorandum, Michigan Department Of Transportation.

Richards, S.H., et. al., (1985, September), ``Improvements and New Concepts for Traffic Control in Work Zones, Volume Speed Control in Work Zones,'' Report No. FHWA/RD 85/037, Federal Highway Administration, Washington, DC.

Richards, S.H., Wunderlich, R.C. and Dudek, C.L., (1985), ``Field Evaluation of Work Zone Speed Control Techniques,'' Transportation Research Record No. 1035, Transportation Research Board, Washington, DC, pp. 66-77.

Graham, J. L., R.J. Paulsen, and J.C. Glennon, ``Accident and Speed Studies in construction Zones,'' Report no. FHWA-RD-77-80, Federal highway Administration, June 1977.

Richards, S.H., M.J.S. Falkner, and C. L. Dudek, ``Traffic Management During Freeway Reconstruction and in Rural Work Zones,'' Report No. 263-7F, Texas Transportation Institute, October, 1982.

Jackels, J. and Brannon, D., ``Work Zone Speed Limit Study on Rural I-35 in Minnesota,'' Minnesota Department of Transportation, Office of Traffic Engineering, St. Paul, MN, November, 1988.

Benekohol, R. F. et. al., ``Speed Reduction Patterns of Vehicles in a Highway Construction Zone, presented at 71st Annual Transportation Research Board Meeting, January, 1992.

Richards, S. H., and Dudek, C.L., ``Implementation of Work Zone Speed Control Measures,'' presented at 65th Annual Transportation Research Board Meeting, January, 1986. Also published in Transportation Research Record 1086.

Missouri Highway and Transportation Department, ``Safety in the Work Zone - Radar Controlled Speed Matrix Signs,'' Jefferson City, MO, 1988.

Noel, E.C., Z.A. Sabra, and C. L. Dudek, ``Use of Rumble Strips in Work Zones, `` Draft Final Report of Contract No. DTFH61-88-X-00007, February, 1989.

Booker, S.C., et. al., ``Supplemental Devices to Enhance Flagger, Safety, `` Transportation Research Record No. 1148, Transportation Research Board, Washington, DC pp. 34-37.

Kemper, W. J., Lum, H.S. and Tignor, S.C., ``The Safety of Narrow Lanes for Traffic Control at Construction Sites,'' Institute of Transportation Engineers Journal, 10(1), Washington, DC, January, 1985, pp. 33-38.

Rouphail, Yang and Fazio, ``A Comparative Study of Short-Term Urban Freeway Work Zones,'' Transportation Research Record No. 1163, Transportation Research Board, Washington, DC, January, 1988, pp. 4-14.

``Speed Control at Work Zones,'' ITE Journal, January, 1988.

``Effect of Radar Drone Operation on Speeds at High Crash Risk Locations,'' Transportation Research Record No. 1464.

```'Drone' Radar Units Have an Effect on Speeds Near Roadway Work Zones,'' Insurance Institute for Highway Safety.

``Speed Control Through Freeway Work Zones: Techniques Evaluation,'' Transportation Research Record 1163.

Speed Control Through Work Zones: Techniques Evaluation and Implementation Guidelines, FHWA-1P-87-4.

Catalog of Work Zone Speed Control Methods, FHWA/TX-9/1161-2, Texas Transportation Institute, 1990.

Work Zone Traffic Management Synthesis: Use of Rumble Strips in Work Zones, FHWA-TS-89-037.
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VITA

DR. JONATHAN EVERETT UPCHURCH, P.E.

Professor
Department of Civil and Environmental Engineering
Arizona State University
Tempe, Arizona 85287-5306
Phone: 602/965-1713
Fax: 602/965-2728
E-Mail: jon.upchurch@asu.edu

EDUCATION

Doctor of Philosophy	University of Maryland	1982
Master of Science in Civil Engineering	University of Illinois	1975
Bachelor of Science in Civil Engineering	University of Illinois	1971

PROFESSIONAL REGISTRATION

Registered Professional Engineer in Arizona (1983) and North Carolina (1976)

AREA OF TEACHING AND RESEARCH

Transportation Engineering, specializing in traffic engineering, traffic operations, transportation planning, geometric design, highway safety and intelligent transportation systems.

PROFESSIONAL EXPERIENCE

August 1982 to present - Civil Engineering Faculty, Department of Civil and Environmental Engineering, Arizona State University. Responsible for conducting transportation research and teaching transportation engineering courses. Taught courses in transportation engineering, urban transportation planning, traffic engineering, highway capacity, intelligent transportation systems, and other courses in civil engineering. Advised masters and Ph.D. level graduate students. Conducted research in traffic engineering, traffic control devices, highway safety, human factors, intelligent transportation systems, and solar energy applications. Published numerous journal papers and technical articles.

July 1988 to December 1989 - Acting Director, Center for Advanced Research in Transportation, Arizona State University. Responsible for administering this research center including promotion of research, supervision of academic professionals and support staff, and budget management.

January 1988 to December 1992 (concurrent with positions above) - International Director, International Vice-President, and International President, Institute of Transportation Engineers. Served as the elected leadership and as a Board of Direction member for this professional society which has 12,000 members in over 70 countries.

December 1979 to December 1988 (concurrent with positions above) - Executive Secretary, National Committee on Uniform Traffic Control Devices. Served as executive administrator for this organization and held complete responsibility for its management. The Committee develops national standards for traffic control devices.

April 1981 to May 1982 - Research Engineer, Office of Research, Federal Highway Administration (on loan from the University of Maryland). Held complete responsibility for research project on re-evaluating traffic control at non-signalized intersections.

September 1980 to March 1981 - Faculty Research Assistant, University of Maryland. Managed an external origin-destination study for the Washington metropolitan area.

August 1976 to August 1980 - Director of Technical Affairs, Institute of Transportation Engineers, Washington, D.C. Responsible for this professional society's technical activities including: administration of the Institute's Technical Council; preparation of annual meeting technical programs; production and marketing of training programs; technical review of two Institute published textbooks; and technical advisement to the society's journal.

July 1975 to July 1976 - Project Manager, Harland Bartholomew and Associates, Raleigh, North Carolina. Managed three studies developing Project Planning Reports and Environmental Impact Statements for improvements in transportation corridors.

August 1972 to June 1975 - Transportation Planner and Traffic Engineer, Harland Bartholomew and Associates, Memphis, Tennessee. Involved in all phases of transportation planning studies and traffic operations programs for medium to large size urban areas.

HONORS, DISTINCTIONS, AND HONORARY ORGANIZATION MEMBERSHIPS

Eagle Scout

Member - Chi Epsilon

Recipient of the Institute of Transportation Engineers Annual Meeting Paper Presentation Award for the outstanding technical paper presented at the 1982 Institute of Transportation Engineers Annual Meeting.

The National Committee on Uniform Traffic Control Devices received the Federal Highway Administration Public Service Award in June, 1985. As part of the award presentation, Dr. Upchurch received a personal letter from the Federal Highway Administrator thanking him for his "outstanding job serving as Executive Secretary of the Committee" from 1979 to 1985.

Received letter of "special commendation for efforts on behalf of ASCE and its Highway Division" for service as Highway Division News Correspondent (1984- 1986).

Each year the Transportation Research Board - a unit of the National Academy of Sciences - selects six transportation research projects which are noteworthy in demonstrating the value of transportation research. In 1988, one of Dr. Upchurch's research projects was selected for this distinction. "New Sign Lighting System Cuts Energy and Maintenance Costs," Transportation Research News, July-August, 1988.

The Arizona Department of Transportation was honored in the Federal Highway Administration's 1990 Biennial Awards for Excellence in Highway Design. ADOT received an Award of Merit in the category of Cost Saving Innovations for its statewide implementation of a high pressure sodium sign lighting system. The sign lighting system was developed by Dr. Upchurch.

Member - Theodore M. Matson Associates - an honorary group of transportation professionals selected for their professional accomplishments.

Recipient - Teaching Excellence Award, College of Engineering and Applied Sciences, ASU, 1994-95.

Recipient of the Institute of Transportation Engineers District 6 Annual Meeting Best Paper Award for the best technical paper presented at the 1996 Institute of Transportation Engineers District 6 Annual Meeting.

SCIENTIFIC AND PROFESSIONAL SOCIETY MEMBERSHIP AND ACTIVITIES

Institute of Transportation Engineers - Fellow	1970 -
Member, Technical Committee 6F-9 - Impact and Responses to the Energy Crisis in Transportation	1975 - 1976
Member and Secretary, Technical Council	1976 - 1980
Member, Technical Standards Evaluation Committee	1979
ITE Delegate to National Committee on Uniform Traffic Laws and Ordinances	1979
Assistant Chairman, Department 1, Technical Council	1982 - 1984
Chairman, Department 1, Technical Council	1984 - 1987
Member, Annual Meeting Technical Program Committee	1982 - 1984, 1988 - 1989
Chairman, Annual Meeting Technical Program Committee	1984 - 1987
Member, Policy Committee	1983 - 1987
Member, Standards Approval Board	1984 - 1987
Member, Research Coordinating Committee	1985 - 1987
Member, Standards Appeals Board	1988 -
Member, Budget Committee	1988 -
Member, District 6 Board of Direction	1988 - 1989
International Board Coordinator, Education and Training	1988 - 1989
Member, ITE Educational Foundation	1988 -
Member, Task Force on Development of ITE Equipment Standards	1989
Member, International Board of Direction	**1988 - 1992**
Chair, Budget Committee	1990
International Vice-President	**1990**
International President	**1991**
Chair, Nominating Committee for International Officers	1992
Chair, Advisory Committee	1992
Member, Advisory Committee	1993 - 1997
Chair, Past President's Award Committee	1992
Member, Past President's Award Committee	1993 - 1994, 1998
Member, Burton W. Marsh Fellowship Selection Committee	1992 - 1994
Chair, Burton W. Marsh Fellowship Selection Committee	1995
Transportation Research Board - Individual Associate Member	1975 -
Member, Committee A3A02 - Traffic Control Devices	1982 - 1987
Secretary, Committee A3A02 - Traffic Control Devices	1988 - 1989
Chairman, Committee A3A02 - Traffic Control Devices	1989 - 1995
Member, Group 3 Council	1995 - 1998
Chair, Section A of Group 3 Council	1997 - 2000
Intelligent Transportation Society of America	
Member, Advanced Traffic Management Systems Committee	1992 -
Member, Advanced Rural Transportation Systems Committee	1992 -
Member, Education Subcommittee	1994 -
Member, State Chapters Council	1995 -
Intelligent Transportation Society of Arizona	
Founding President	1994 - 1995
Past President	1995 - 1996
Director-at-Large	1996 - 1998

American Society of Civil Engineers - Member — 1972 -

Member, Highway Division Research Committee	1983 - 1988
Member, Urban Transportation Division Traffic Operations Committee	1983 - 1989
Highway Division News Correspondent	1984 - 1986
Member & Secretary, Highway Division Executive Committee	1986 - 1988
Contact Member, Highway Division Publications Committee	1986 - 1989
Contact Member, Highway Division Education Committee	1987 - 1989
Member, Highway Division Executive Committee	1988 - 1989
Reviewer, Journal of Transportation Engineering	1994

National Committee on Uniform Traffic Control Devices

Executive Secretary	1979 - 1988
Member, Research Committee	1983 -
Member, Construction and Maintenance Technical Committee	1989 -
Associate Member representing the National Safety Council	1989 - 1990
Associate Member representing the Institute of Transportation Engineers	1991 - 1997
Member representing Institute of Transportation Engineers	1997 - 2001

American Society for Engineering Education
Member — 1992, 1995-1997

National Academy of Sciences/National Research Council

National Cooperative Highway Research Program

Member, Project Panel G17-7, "Guidelines for Converting Stop to Yield Control at Intersections"	1984 - 1989
Member, Project Panel G3-41, "Procedure for Determining Work Zone Speed Limits"	1989 -
Member, Project Panel G17-16, "Accident Warrant for Traffic Signals"	1996 -
Member, Synthesis Panel 23-11, "Changeable Message Signs"	1991 - 1996
Member, Synthesis Panel 29-02, "Roadway Incident Diversion Practices"	1997 -

Participant, Institute of Transportation Engineers European Study Tour on Intelligent Vehicle/Highway Systems — 1991

Participant, Institute of Transportation Engineers Japan Study Tour on Intelligent Vehicle/Highway Systems — 1992

Chair, Maricopa County ITS Strategic Plan Steering Committee — 1994 - 1995

Member, Maricopa Association of Governments Regional Council, Intelligent Transportation Systems Committee — 1996 -

Participant, Arizona Town Hall, "Forging an Appropriate Transportation System for Arizona." May, 1997.

Member, Governor's Task Force on High Speed Rail Transportation — 1997 - 1998

SPONSORED PROJECTS RELATED TO TRAFFIC CONTROL DEVICES

At the University of Maryland:

Research

Principal Investigator, "Re-evaluation of Traffic Control at Non-Signalized Intersections," sponsored by the Maryland State Highway Administration. November 1981 - June 1983.

Principal Investigator, "Use of Yield, Two-way Stop, and Four-way Stop Control at Moderate Volume Intersections," sponsored by the Federal Highway Administration. April 1981 - June 1982.

At Arizona State University:

Research

Co-Principal Investigator (Judson Matthias also served as Co-PI), "Left Turn Signal Warrants for Arizona," sponsored by Arizona Department of Transportation. May 1983 - May 1985.

Principal Investigator, "Evaluation of Alternative Light Sources for Guide Sign Illumination," sponsored by Arizona Department of Transportation. December 1983 - April 1986.

Principal Investigator, "Consultant Services for Evaluation of MUTCD Criteria," sponsored by COMSIS Corporation and the Federal Highway Administration. September 1984 - January 1986.

Principal Investigator (Paul Russell also served as Co-PI), "Use of Solar Energy for Lighting of Overhead Guide Signs, Roadway Lighting, and Intersection Traffic Signals," sponsored by the Arizona Department of Transportation. March 1986- June 1988.

Principal Investigator, "Evaluation of Non-Illuminated Guide Signs," sponsored by Arizona Department of Transportation. September 1986 - January 1987.

Principal Investigator (Judson Matthias and Essam Radwan also served as Co-PIs), "Development, Evaluation, and Application of Left Turn Signal Warrants," sponsored by Arizona Department of Transportation. January 1987 - June 1990.

Co-Principal Investigator, (Essam Radwan also served as Co-PI), "Effect of Right Turning Vehicles on Traffic Signal Volume Warrants," sponsored by Arizona Department of Transportation. June 1987 - September 1987.

Principal Investigator, "Safety and Operational Impacts of Raising the Speed Limit to 65 MPH," sponsored by Arizona Department of Transportation. October 1987 - April 1989.

Principal Investigator, "Evaluation of Variable Message Signs," sponsored by Kimley-Horn and Associates and Arizona Department of Transportation, September, 1990-May, 1991.

Principal Investigator, "Field Evaluation of Minimum Retroreflectivity Guidelines for Traffic Signs," sponsored by Arizona Department of Transportation and Federal Highway Administration, October, 1994 - January, 1995

Principal Investigator, "Development of National Traffic Control Device Standards," sponsored by TONYA, Inc. and Federal Highway Administration, April-August, 1995

Other Sponsored Projects

Director, "Secretariate Services for the National Committee on Uniform Traffic Control Devices," sponsored by the American Association of State Highway and Transportation Officials and the National Committee. August 1982 - December 1988.

Director, "Highway Risk Management Workshop for Cochise County," sponsored by Cochise County. March-May, 1990.

PUBLICATIONS RELATED TO TRAFFIC CONTROL DEVICES

Archival Refereed Journal Papers (Papers selected for publication based upon peer/technical review of the entire paper; paper subject to possible rejection based upon the review)

"Characteristics of Reversible Flow on a Six Lane Urban Arterial," Traffic Engineering, December, 1975, pp. 11-14.

"Guidelines for Use of Sign Control at Intersections to Reduce Energy Consumption." Published in Institute of Transportation Engineers Journal as winner of the ITE Annual Meeting Paper Presentation Award, January, 1983, pp. 22-34.

"Changes to MUTCD Adopted." Institute of Transportation Engineers Journal, April, 1983, pp. 48-49.

"New Traffic Control Device Standards." Institute of Transportation Engineers Journal, April, 1984, pp. 43-46.

"Recent Changes to the Manual on Uniform Traffic Control Devices." Institute of Transportation Engineers Journal, August, 1985, pp. 25-27.

"Guidelines for Selecting Type of Left Turn Phasing," Transportation Research Record 1069, National Academy of Sciences/Transportation Research Board, 1986, pp. 30-38.

"Changes to the Manual on Uniform Traffic Control Devices." Institute of Transportation Engineers Journal, June, 1986, pp. 41-43.

"Evaluation of Alternative Sign Lighting Systems to Reduce Operating and Maintenance Costs," Transportation Research Record 1111 (co-authored with Jeffrey T. Bordin), National Academy of Sciences/Transportation Research Board, 1987, pp. 79-91.

"Conversion from Permissive to Exclusive/Permissive Left Turn Phasing: A Before/After Evaluation," Transportation Research Record 1114 (co-authored with Anne Stonex), National Academy of Sciences/Transportation Research Board, 1987, pp. 63-71.

"Identification of Needed Traffic Control Device Research," Transportation Research Record 1114 (co-authored with Phillip S. Shapiro, John Loewen, and Vic Siaurusaitis), National Academy of Sciences/Transportation Research Board, 1987, pp. 11-20.

"New MUTCD Standards." Institute of Transportation Engineers Journal, March, 1987, pp. 41-44.

"Use of Photovoltaic Power Supply for Highway Engineering Applications," Australian Road Research. September, 1988. Australian Road Research Board, pp. 162-172.

"Major Changes in Traffic Control Device Standards." Institute of Transportation Engineers Journal, June, 1988, pp. 24-28.

"The 1988 Edition of the Manual on Uniform Traffic Control Devices," Institute of Transportation Engineers Journal, April, 1989, pp. 17-19.

"Arizona's Experience with the 65 Mile per Hour Speed Limit," Transportation Research Record 1244, National Academy of Sciences/Transportation Research Board, 1989, pp. 1-6.

"A Comparison of Left Turn Accident Rates for Different Types of Left Turn Phasing," Transportation Research Record 1324, National Academy of Sciences/Transportation Research Board, 1992, pp. 33-40.

"Reducing Delay to Left Turning and Through Vehicles: A Study of Three Signal Conditions," Transportation Quarterly, (co-authored with Thomas R. Warne), January, 1992, pp. 81-98.

"A Before and After Comparison of Leading Exclusive and Permissive/Exclusive Lagging Left Turn Phasing," Transportation Research Record 1368 (co-authored with Charles R. Wright), National Academy of Sciences/Transportation Research Board, 1992, pp. 31-38.

"Evaluation of Variable Message Signs: Target Value, Legibility and Viewing Comfort," Transportation Research Record 1376 (co-authored with Jeffrey Armstrong, M. Hadi Baaj, and Gary Thomas), National Academy of Sciences/Transportation Research Board, 1992, pp. 35-44.

"Human Factors Design Considerations for Variable Message Freeway Signs," Journal of Transportation Engineering, American Society of Civil Engineers (co-authored with Jeffrey Armstrong), Vol. 120, No. 2, March/April 1994, pp. 264-282.

"Effect of Non-Optimal Cycle Lengths and Traffic Volumes on Progression," Institute of Transportation Engineers Journal (co-authored with Gary B. Thomas), accepted for publication.

Other Refereed Papers and Publications (Paper selected for publication based upon peer/technical review of the entire paper, subject to possible rejection based on the review).

"Intersections" (chapter co-authored with George F. Hagenauer, Davey Warren, and Merton J. Rosenbaum). Synthesis of Safety Research Related to Traffic Control and Roadway Elements. Federal Highway Administration Publication FHWA-TS-82-233, December, 1982, pp. 5-1 to 5-21.

"Research Pays Off: New Sign Lighting System Cuts Energy and Maintenance Costs." Transportation Research News, July-August, 1988, National Academy of Sciences/Transportation Research Board, pp. 14-15.

Papers presented at National Meetings (Paper selected for publication based upon peer/technical review of an abstract; subject to possible rejection based on the review.)

"Development of Traffic Control Device Standards." Compendium of Technical Papers (Proceedings), Institute of Transportation Engineers 54th Annual Meeting, September, 1984, pp. 11-1 to 11-5.

"Development of Traffic Control Device Standards: 1985 Amendments to the Manual on Uniform Traffic Control Devices." Proceedings, Institute of Transportation Engineers District 6 - 38th Annual Meeting, July, 1985, pp. 226-231.

"Manuals on Uniform Traffic Control Devices: A Comparison of Canadian and United States Manuals." (co-authored with Al Maurer). Proceedings, Institute of Transportation Engineers Districts 6 and 7 Annual Meeting, July, 1986, pp. 3-1 to 3-12.

"1986 Amendments to the MUTCD: Changes That Every Traffic Engineer Should Know." Compendium of Technical Papers (Proceedings), Institute of Transportation Engineers 56th Annual Meeting, September, 1986, pp. 215-219.

"Do We Need New Traffic Control Device Standards?" Proceedings, Institute of Transportation Engineers District 6 - 40th Annual Meeting, July, 1987, pp. GG-1 to GG-9.

"Solar Energy: Use of Photovoltaics for Traffic Engineering and Highway Engineering Applications," Proceedings, Institute of Transportation Engineers District 6 - 41st Annual Meeting, July, 1988, pp. 337-347.

"The 1988 Edition of the Manual on Uniform Traffic Control Devices: What's New and Different?," Proceedings, Institute of Transportation Engineers District 6 - 41st Annual Meeting, July, 1988, pp. 69-76.

"Nighttime Visibility: A New Cost Effective Sign Lighting System." Compendium of Technical Papers (Proceedings), Institute of Transportation Engineers 59th Annual Meeting, September, 1989, pp. 427-431.

"A Human Factors Evaluation of Freeway Guide Sign Lighting Systems." Proceedings, Human Factors Society 33rd Annual Meeting (co-authored with Jeffrey T. Bordin), October, 1989, pp. 615-619.

"Variable Message Signs as Part of Smart Streets," (co-authored with Jeffrey Armstrong). Proceedings, Institute of Transportation Engineers District 6 - 44th Annual Meeting, July, 1991, pp. 210-222.

"A Human Factors Evaluation of Alternative Variable Message Sign Technologies," (co-authored with Jeffrey Armstrong, Gary Thomas, Hadi Baaj). Conference Record of Papers, 3rd International Conference on Vehicle Navigation and Information Systems, September, 1992, pp. 262-267.

"A Human Factors Analysis of Three Variable Message Sign Technologies." Proceedings, 20th Summer Annual Meeting of The Planning and Transport Research and Computation International Association (PTRC), September, 1992, pp. 37-48.

"The Use of Variable Message Signs in Advanced Traffic Management Systems: An Example of Human Factors Considerations in IVHS," (co-authored with Jeffrey Armstrong, Gary Thomas, Hadi Baaj). Vehicle Systems for Roads (SP - 989), Society of Automotive Engineers, November, 1993, pp. 91-102.

"Motorist Perceptions of Ramp Metering: The Phoenix Area Experience," (co-authored with Daniel Cleavenger). Proceedings, Institute of Transportation Engineers District 6 - 49th Annual Meeting, July, 1996. This paper received the Best Paper Presentation award at the District 6 Annual Meeting.

"New National Retroreflectivity Standards: The Impact on One State Department of Transportation," (co-authored with Brian Curtis). Proceedings, Institute of Transportation Engineers District 6 - 49th Annual Meeting, July, 1996.

"Effect of Freeway Ramp Metering on Accidents: The Arizona Experience," (co-authored with Daniel Cleavenger). Proceedings, Institute of Transportation Engineers District 6 - 50th Annual Meeting, July, 1997.

"Evaluation of Different Signing Treatments for Controlling Speeds on Urban Arterial Streets," (co-authored with Satyaprakash Kakulavaram). Proceedings, Institute of Transportation Engineers District 6 - 50th Annual Meeting, July, 1997.

Other Publications

"Work Site Safety." Applying Research to Arizona Roads Newsletter, October, 1985, pp. 4-6.

"New Traffic Control Device Standards Affect Local Agencies." Applying Research to Arizona Roads Newsletter, January, 1989, pp. 4-6; Montana Rural Technical Assistance Program Quarterly Newsletter, September, 1989, pp. 1-3; Oregon Roads Newsletter, Special Edition - 1989, pp. 1-4.

Reports

Left Turn Signal Warrants for Arizona, Arizona Dept. of Transportation (with Judson S. Matthias), June, 1985.

Evaluation of Alternative Lighting Systems for Guide Sign Illumination, Arizona Department of Transportation (with Jeffrey T. Bordin), April, 1986.

Evaluation of Non-Illuminated Guide Signs: State-of-the-Art Report. Arizona Department of Transportation, August, 1987.

Effect of Right Turning Vehicles on Traffic Signal Volume Warrants: State-of-the-Art Report, Arizona Department of Transportation (with Essam Radwan), November, 1987.

Use of Solar Energy for Lighting of Overhead Guide Signs, Roadway Lighting, and Flashing Warning Lights, Arizona Department of Transportation (with Paul E. Russell and Edward F. McBrien), February, 1989.

Safety and Operational Impacts of Raising the Speed Limit to 65 MPH, Arizona Department of Transportation, April, 1989.

Development, Evaluation and Application of Left Turn Signal Warrants, Arizona Department of Transportation (with Essam Radwan and Arthur Dean), August, 1991.

Evaluation of Variable Message Signs, Kimley-Horn and Associates and Arizona Department of Transportation (with M. Hadi Baaj, Jeffrey D. Armstrong, and Gary B. Thomas), July, 1991.

An Impact Analysis of Traffic Sign Replacement on Arizona's Highways to Meet Retroreflectivity Standards, Arizona Department of Transportation and Federal Highway Administration (with Brian Curtis), February, 1995.

ARIZONA DEPARTMENT OF TRANSPORTATION
Joint Project Administration

Progress Final Payment Report

Report No.	FA	Non FA	Exp. Budget Obj. Code	Contract No.

TRACS No.
Project No. Date Ending

Name of Project:

Name Of Consultant:

Date Started	Estimated Completion Date:	% Billed	% Complete

SUMMARY OF WORK FOR WHICH PAYMENT IS REQUESTED

Item	Description	Total Contract Amount	Previous Accumulative Amount	Current Month	Accumulative Amount

Submitted By: _____ Date _____
Consultant

Approved By: _____ Date _____
ADOT Project Monitor

Approved By: _____ Date _____
Joint Project Administration

Total To Date	
Total Previous Report	
Current Report	